THE EFFECT OF STAGE OF MATURITY AND THE ADDITION OF UREA AND COTTONSEED MEAL ON THE ENSILING QUALITIES OF SWEET SORGHUM AND THE FEEDING VALUE OF THE SILAGE

BY

ARTHUR EDISON CULLISON

B.S., University of Illinois, 1936
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ACKNOWLEDGMENTS

The author wishes to express grateful appreciation to the Graduate School of the University of Illinois for the privilege of developing this thesis in absentia; to the members of his advisory committee, Dr. W. E. Carroll, Dr. T. S. Hamilton, and Dr. W. B. Nevens of the University of Illinois for their help and patient cooperation in setting up and carrying out the thesis project; to Director M. J. Funchess of the Alabama Experiment Station for the privilege of conducting the thesis research under his jurisdiction; to Professor J. C. Grimes, Head of the Animal Husbandry Department, Alabama Experiment Station and Professor W. D. Salmon, in charge of Animal Nutrition, Alabama Experiment Station, for their many helpful suggestions and for making available most of the facilities, equipment, and materials for conducting this research; to Professor J. M. Robinson, Head of the Zoology Department, Alabama Experiment Station for the use of a potentiometer belonging to his Department; to Dr.

R. UNIV. BIBLIOTHEEK LEIDEN

Leonard Ensminger of the Agronomy Department, Alabama Experiment Station for making a pH meter in his laboratory available for pH determinations; to Professor Gordon Hughes of the Physics Department, Alabama Polytechnic Institute and Mr. J. H. Ramser of the Agricultural Engineering Department, University of Illinois, for their helpful suggestions in setting up the thermocouples for temperature determinations; to Dr. T. A. Bancroft in charge of the Statistical Laboratory, Alabama Polytechnic Institute, for his assistance in the statistical interpretation of much of the experimental data; to Dr. R. W. Engel of the Nutrition Laboratory, Alabama Experiment Station, for his many helpful suggestions; to Arthur Shroder, Director of Research, E. H. Sargent and Company for suggesting the use of a Bunsen valve as a means of releasing the fermentation gases from the miniature silos used in this study; to M. F. Gribbons, Technical Service Section, E. I. duPont De Nemours and Company, for supplying the urea used in this work; and to all others whose kind cooperation helped to make this thesis possible.

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In the use of sweet sorghum for ensiling purposes there frequently results a prolonged fermentation and/or a silage of low acceptability and feeding value. Preliminary studies indicated that these irregularities might be the result of low available nitrogen supply in the sweet sorghum plant. Stage of maturity of sweet sorghum has also been regarded as an important factor bearing on the quality of silage made from this crop. As a result a study was conducted to obtain definite information on the effect of both stage of maturity and certain nitrogen supplements on the ensiling qualities of sweet sorghum and the feeding value of the resulting silage.

A trench-type silo divided longitudinally into three sections with board walls lined with roofing paper was used for the feed-lot phase of this work. Sweet sorghum in the late-dough stage of maturity was ensiled in the three silo sections using no treatment, 10 pounds of urea per ton, and 80 pounds of cottonseed meal per ton (approximately the nitrogen equivalent of 10 pounds of urea), respectively.

A feeding trial was conducted with three lots of coming-2-year-old cattle fed at equal TDN levels on the three silages. The three lots of cattle performed quite similarly during an 84-day wintering period with the cattle in each of the lots suffering a slight loss in weight.

No significant differences were noted in the acceptability of the three silages. While the CSM-treated silage was consumed with somewhat more relish than the other two silages, it was felt that this was due to the direct effect of the cotton-

seed meal rather than to a more desirable fermentation in this silage.

Temperatures as measured with buried thermocouples were higher throughout the ensiling period for the urea and the cottonseed meal-treated silages, and the untreated silage was significantly higher than both atmospheric and soil temperatures as long as five months after filling the silo.

Dry matter losses during ensiling were measured by the buried-sack method. Mean differences in dry matter losses for the different silages were of doubtful significance. There was an overall average dry matter loss of 19.06 percent for the three silages of the feed-lot silo.

Minature silos consisting of two-quart glass jars each equipped with a number 12 one-holed rubber stopper carrying a convential Bunsen valve for the escape of fermentation gases proved highly successful for experimental silage production. Silos of this type were used for ensiling sweet sorghum in the milk, late-dough, and mature stages of maturity. All three stages of sweet sorghum were ensiled with no treatment, with the addition of 10 pounds of urea per ton, with the addition of 5 pounds of urea per ton, and with the addition of 80 pounds of cottonseed meal per ton. Each treatment of each stage was set up in duplicate.

Sweet sorghum of the three different stages of maturity was analyzed for dry matter, crude protein, reducing sugars after inversion, and carotene.

Dry matter content of the sorghum increased with maturity from 18.07 percent in the milk stage to 22.92 percent in the late-dough stage and 26.07 percent in the mature stage. Crude protein percent was fairly constant for the different stages (1.24%, 1.30%, and 1.25%, respectively) on the fresh basis but on the dry basis decreased considerably with advancing maturity.

The percentage of reducing sugars on the fresh basis increased with advancing maturity but did not change signifi-

cantly on the dry matter basis. On the average reducing sugars made up 30.5 per cent of the dry matter of the sweet sorghum plant. It was noted, however, that upon being stored in a refrigerator at 38° F. for two weeks the milk-stage sorghum lost 94.6 percent of its initial reducing sugars, the late-dough stage 15.9 percent, and the mature stage 65.2 percent.

The carotene picture for the three stages of sweet sorghum also present an interesting but somewhat puzzling picture. The carotene value obtained for the crop in the late-dough stage was significantly higher than that obtained for the milk-stage sorghum. The comparatively more favorable growing conditions just prior to harvesting the late-dough stage sorghum may have been a factor in this difference. As would be expected the mature stage sorghum yielded the lowest carotene value.

The silages from the feed-lot silo were sampled for analysis at the begininng, midway, and toward the end of the feeding period. The silages from the duplicate set of miniature silos were analyzed at the end of ensiling periods of 4 and 9 months, respectively. The various silages were analyzed for dry matter, crude protein, reducing sugars, carotene, ammonia, urea, pH, total free and combined acidity, total free acidity, lactic acid, acetic acid, butyric acid, and amino acids.

All dry matter determinations on silages were corrected for losses of volatile acids and bases during drying which under the drying conditions of this study (110° C for 24 hours) were found to be equal to approximately 100 percent of the volatile acids and 33.7 percent of the ammonia present. A small but significant decrease in the dry matter content of the silages of the miniature silos occurred during the first four months with no significant change in dry matter content thereafter.

Mean differences for dry matter losses from the miniature silos were not significant at the 5 percent point. The dry matter loss for all the miniature silos was only 5.89 percent whereas it was 19.06 percent for the feed-lot silo. This condition was attributed to the absence of any drainage of juices

from and a more completely anaerobic condition in the miniature silos.

No significant losses of crude protein from the different silages during the ensiling period were noted. In fact apparent increases in the percent of crude protein were obtained in several instances, especially with the silages from the feed-lot silo. This was attributed to the loss of dry matter other than nitrogen from the silage material during the ensiling process.

The sugar level of the different silages at the end of the ensiling period was in general less than one-half that of the fresh sweet sorghum. The untreated silages were on the average highest in sugar content, and the CSM-treated silages were lowest. Consistent with the more stable nature of the reducing sugars in the late-dough stage sorghum mentioned earlier was the fact that the silages made from sorghum of this stage retained a greater portion of their initial sugar content during the ensiling process than did the silages made from the older and younger crop.

The carotene content of the different silages varied greatly and did not present a uniform picture. Carotene values for certain of the silages were considerably higher than those of the crop at the time it went into the silo. Some of the greatest apparent increases in carotene were with the silages made from sorghum in the milk stage. Certain of the silages known to have been subjected to more or less air penetration were among the lowest in carotene content.

Of the urea nitrogen initially added to the urea-treated silages 82.2 percent was still present at the end of the ensiling period as either urea or ammoniacal nitrogen. There was a much greater decomposition of urea during the ensiling process in the feed-lot silo than in the miniature silos.

It is apparent from the above that not over 17.8 percent of the original urea application could have been converted to protein by the silage micro-organisms during the ensiling process.

A negative correlation of $r = -.83$ (significant at the 1%

point) was found to exist between hydrogen ion concentration and total combined acidity, the latter consisting principally of amino acids and ammonium salts of organic acids. There seemed to be little direct relation between hydrogen ion concentration and total free acidity. In general the greater the amount of combined acidity the greater was the amount of all other types of acidity, but the higher the pH.

The proportion of lactic to acetic acid in the various silages from the miniature silos was 1:0.41, which is a higher proportion of lactic acid than is usually found in other types of silage. A high proportion of lactic acid is normally regarded as being desirable.

In only four of 33 possible instances was there the slightest amount of butyric acid present. All three samples of urea silage and one sample of CSM silage from the feed-lot silo yielded traces of this product.

By connecting jars of the various silages with a gas absorption train it was possible to study carbon dioxide production and ammonia losses during the ensiling process. Most of the fermentation gases were produced during the first week following the filling of the silos with essentially no gas being produced by any of the silages after the second week.

The production of carbon dioxide by the different silages seemed to parallel fairly closely the total acidic fermentation in these silages. There was not the slightest trace of ammonia lost from any of the silages, the pH's of which were all under 4.00.

Conclusions

On the basis of the results of the present study, the following conclusions seem justified:

1. Some factor or factors other than or in addition to the available nitrogen supply is responsible for the undesirable nature of the fermentation process frequently experienced in

the ensiling of sweet sorghum.

2. The percent of reducing sugars in fresh sweet sorghum rises with advancing maturity on the wet basis but does not change significantly on the dry matter basis.

3. The stability of the reducing sugars in sweet sorghum varies greatly, but does not seem to vary directly with stage of maturity.

4. In the presence of adequate fermentable sugars, the pH of the silage mass is largely dependent on the amounts of amino acids and replaceable amonia present.

5. In the presence of varying amounts of amino acids and ammonia, there is no direct relation between total free acidity and pH.

6. There is no apparent relation between the losses of carotene during ensiling and the nature and extent of the normal fermentation process.

7. There is no loss of gaseous ammonia from silages with pH's of less than 4.0.

8. Only sheltered silos should be used for conducting silage investigations.

9. The use of miniature silos such as were used in this study not only offers a very satisfactory, convenient technic for studying basic fermentation processes in connection with different types of silages and silage treatments, but also makes possible a completely controlled experimental set-up the results of which lend themselves especially well to statistical analysis.

VITA

The author, Arthur Edison Cullison, was born in Lawrence County, Illinois, October 30, 1914, and received his elementary and high school education in public schools of that county.

He entered the University of Illinois as a Freshman in September, 1932, and received his B.S. degree in Agriculture in June 1936 and his M.S. degree in Animal Husbandry from the same institution in October of 1937. After nearly two more years of part-time graduate study at this same University he passed his preliminary examinations for the doctorate in June, 1939.

In August of 1939 the author joined the Animal Husbandry Staff of Mississippi State College and the Mississippi Experiment Station where he served as a teacher and research worker until he entered the Army in May, 1943. In the Army he served in the capacity of a Food and Nutrition Officer, leaving the Service as a Captain in July, 1946. Upon leaving the Service, the author joined the Animal Husbandry Staff of Alabama Polytechnic Institute and the Alabama Experiment Station where he was employed until September 1, 1948. At this time the author's appointment as head of the Animal Husbandry Department of the University of Georgia became effective.

The author is a member of the following honorary groups — Alpha Zeta, Gamma Sigma Detla, Phi Kappa Phi, Bronze Tablet, and Sigma Xi.

Following is a list of his publications:

1. The influence of breeding on the performance of beef calves produced in Mississippi. Miss. Agr. Expt. Sta. Bul. 347 (1941).

2. The use of urea in making silage from sweet sorghum. Jour. An. Sci. 3:59-62 (1944).

Numerous articles on beef cattle feeding in the 1940-1943 issues of Mississippi Farm Research.

The author was married to Corenne Pence, Illinois '37, July 1, 1939 and has two children — Diane, 5 years and David, 2 years.